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Study on Increase the Dosing Efficiency of Auger Filling Unit by Improving Bulk Density of Powder

[1]Vishal Papade,[2]Galhe D. S.,[3]Sameer Palker,[4]Pawar P.S.,[5]Dhoble A.L

[1]Research Scholar, Dept. Mechanical 1Jaihind College of Engg. SPPU Pune, India
vishal.papade07@gmail.com
[2]Professor, Dept. of Mechanical ,Jaihind College of Engg. SPPU Pune, India
datta.dsgl@gmail.com 3NPD Engineer at RIPL Pune
[3]Trinity College of Engg. SPPU Pune, India smrpalkar@gmail.com
[4]HOD & Assistant Prof., Dept. of Mechanical Jaihind College of Engg. SPPU Pune, India
pareshpawar.jcoe@gmail.com
[5]Assistant Professor, Dept. Mechanical, Jaihind College of Engg. SPPU Pune, India
arvinddhobale.jcoe@gmail.com

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Abstract

This research aims to investigate the factors contributing to variations in the filling weight of an auger filling machine, explore potential methods for improving filling weight consistency, and assess the improvements after implementing those methods. The study began with a brainstorming session involving engineers and technicians to identify key factors influencing filling weight. These factors included screw design, product bulk density (BD), the presence of dust, and moisture content in the product being filled. The analysis revealed that variations in the product's bulk density and dust content were significant contributors to filling weight inconsistencies. Subsequently, experiments were designed to test methods for improving filling accuracy. The results demonstrated that using a vacuum system in the auger casing effectively increased the product’s bulk density, leading to enhanced filling accuracy. As a result, the filling accuracy improved from ±2.5% to ±1%.

Keywords: Design, SolidWorks, Powder Packaging, Auger Filling Machine, Filling Improvement.

I. INTRODUCTION

An auger filler machine is a device commonly used in the packaging industry to accurately dispense and fill powdered or granular products into containers such as bags, bottles, or boxes. It utilizes an auger, which is a spiral-shaped screw, to measure and dispense the desired quantity of the product. Here’s a general overview of how an auger filler machine works:

Product Hopper: The machine features a sizable hopper used for storing the product. Auger filling machines, particularly those manufactured in China, commonly have hopper volumes of 15L, 20L, 50L, and 100L. The hopper serves as a temporary storage for materials and feeds the product into the auger system.
Auger System: The auger comprises a long metal screw, which is enclosed within a funnel-shaped tube. This screw runs from the hopper's base to the filling area. A motor connected to the auger controls its rotation.
Filling Area: Typically, the filling area includes a funnel or nozzle where containers are placed for filling. Depending on the machine's design, containers can be positioned either manually or automatically.
Rotation and Measurement: As the auger turns, it moves product from the hopper through its length. The spiral design of the screw pushes the product forward, creating a void behind it to facilitate the movement of more material.
Product Dispensing: The product continues along the auger until it reaches a cutoff blade or valve mechanism at the end. This mechanism regulates the flow of the product and ensures the correct amount is dispensed into the container.
Container Filling: When the valve or cutoff blade opens, the product is released from the auger and falls into the container. The auger's rotation is often synchronized with the container's position to ensure precise and uniform filling.
Repeat Process: The auger continues to rotate, pulling more product from the hopper and filling additional containers until the desired number of containers is filled.

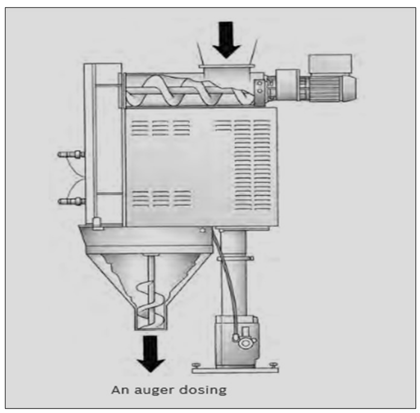

Fig. 1 Auger Filler Machine.

II. LITERATURE REVIEW

One of the key challenges in this area is ensuring consistent and accurate dosing of low-dose drug products [1]. Dry granulation has emerged as a preferred approach for manufacturing low-dose formulations, as it offers advantages over wet granulation in terms of stability and process efficiency. However, the flow and compaction properties of the powder blend can significantly impact the performance of the auger filling unit, which is a critical step in the manufacturing process. [2]

Granulation, a common step in pharmaceutical processing, is known to be one of the most variable steps in the manufacturing chain. Factors such as powder characteristics, granulator type, and process parameters can all contribute to the variability in the granulated product. The variability in pharmaceutical granulation can lead to issues with content uniformity, segregation, and other problems that impact the performance of downstream unit operations like auger filling.

Powder processing is at the heart of pharmaceutical manufacturing, and as a result, current trends are leading to an increased emphasis on efficient, knowledgeable powder handling. Improving the bulk density and flow properties of powder blends can be an effective way to optimize the performance and consistency of auger filling units, as these characteristics directly impact the behavior of the powder during the dosing process [2].

To address these challenges, researchers have explored strategies to optimize the granulation process and enhance the bulk density of the powder blend. One approach is to use dynamic powder characterization techniques, which can provide insights into the flow and compaction behavior of the powder blend. Another approach is to carefully select the excipients used in the formulation, as the physicochemical properties of the excipients can significantly impact the behavior of the powder blend. [3]

Sumeth Singphu, Sombat Teekasap, Supawadee Theerathammakorn studied Filling improvement of the face powder with auger filler machine to reduce the variability of the filling weight. Summary of research results Packaging face powder using a spiral packaging machine to reduce variation in packaging weight. The results can be summarized as follows. 1. There are 3 factors affecting the variation in the flour filling weight of the spiral flour packaging machine: the distance between the filling spiral and the spiral jacket. Packing thread pitch Packing speed 2. The distance between the filling thread and the thread jacket affects the variation of the filling weight. The distance between the thread and the thread jacket must be set to a minimum.[4]

Schiano Moriello on behalf of Biopharma Process Systems (BPS), studied Product dusting during the dispense contributes to unnecessary wastage, increased cleaning and H&S protocols, whilst also influencing the discrepancy between the weight of the fills.[5]

Previous research has shown that the bulk density of the powder blend is a key parameter that can influence the performance of auger filling units. Powders with higher bulk densities tend to flow more consistently and fill the auger cavities more uniformly, leading to improved dose accuracy and content uniformity.

III. OBJECTIVES OF RESEARCH

The research aims to find out problems solutions regarding more cost, heavyweight, transportation, storing, handling, etc.

- Use of vacuum to remove air from the product during filling from the auger filler by using benefits of loose & tapped bulk density
- Selection of proper feeding screw and use of vacuum to convert loose BD into tapped BD will increase the dosing accuracy of the system.
- Increase in accuracy and reduction in dust formation will increase the production rate, reduce the laminate wastage and helps in cost saving.
- Use of vacuum connected to the screw tube will resist the formation of dust and hence avoiding the hazardous effects on system and human also.

IV. METHODOLOGY

As one of the most popular filling machines, the auger filling machine works on a straightforward principle. After bulk materials are fed into the hopper, the auger drive keeps the auger rotating at a constant speed to move the materials down to the funnel. The agitator blade is operated and controlled separately. The agitator blade rotates in the opposite direction of the auger. It works to get rid of air in the powders, making the mixture more uniform.

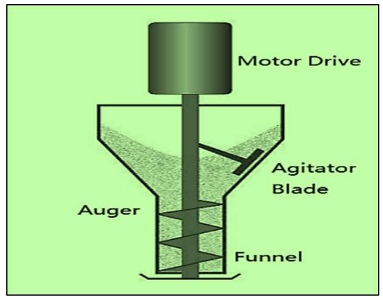

Fig. 2 Straightforward Principle.

The agitator blade is operated and controlled separately. The agitator blade rotates in the opposite direction of the auger. It works to get rid of air in the powders, making the mixture more uniform. Further, the agitator blade is designed to go all the way down to the funnel. This keeps rat-holing and cavitation from happening and ensures that the auger flights are always packed with the products. The auger flights are spaced at the same distance. This ensures that each fighting pitch is filled with ingredients of the same bulk density and particle size. It helps achieve precise dosing as the auger rotates. The tooling used in the auger filling machine consists of the auger, agitator blade, and funnel. These components are all replaceable units depending on the product properties, fill weight, container neck finish, and other factors. Auger is vertically rotated within the hopper to convey the product downward and feed it out of the funnel.

Fig. 3 Auger Screw Set-up.

Fig. 4 Screw.

1.1. The screw selection considering screw calculations for 1000 gm, screw diameter 67 mm & pitch 60 mm is as follows:

1.1. Table 1: Screw Selection Parameters.

Screw Selection			
Section	**Parameter**	**Value**	**Unit**
Sales Input	Pack Wt.	1000	gms
	B.D.	0.5	gm/cc
	DFR		
Constant	Auger Screw Dia.	67	mm
	Core Dia.	15	mm
	Flute Thickness:	2	mm
	Screw Pitch:	60	mm
	Filling efficiency:	85	%
	Motor Speed	4000	rpm
	Motor Acceleration	10000	rpm
	Motor Deacceleration	10000	rpm
	Motor Profile	1	no
	Auger Screw Reduction Ratio	2.571428571	
Calculated	Screw Dia.	6.7	cm
	Core Dia.	1.5	cm
	C/ Area	33.4893776	sq. cm
	Flute thickness	0.2	cm
	Effective Pitch	5.8	cm
	Filling Efficiency	0.85	-
	Volume/pitch	165.102632	cc
	Weight/Pitch	82.551316	Gm
	Total Shaft Revolutions	12.1136772	Rotations
	Total Motor Rotation	31.1494558	Rotations
	Distance	11213.8041	Deg
Output	Volume Per Pitch	165.102632	cc
	Filling Time	867.241837	msec
	Max Auger Speed with No In b/w Dump Delay	69.1848541	dpm

V. NEW DESIGN MODIFICATION

1.2 *A. The new design modification suggested are as follows:*

a. Modification of the outer tube of the auger.
b. Selection of pump to generate the vacuum.
c. Selection of auger chamber size

d. Mesh selection to avoid product suction: Aim is to suck the air available inside the powder.
e. Design of screw to sustain stresses & torque develop by the motor & product.
f. Compression ratio we get.

B. Loose BD & Tapped BD of the Product:

Powder bulk density is the density of the bulk of the particles, included the voids in between each particle. The two bulk densities are usually measured:(i) Loose Density, (ii)Tapped Density.

Bulk Density Measurement:

- Measuring loose bulk density:
  When measuring the loose density, the powder must be in its aerated state.
- Measuring tapped bulk density:
  When measuring tapped density, a step of powder compaction is necessary.

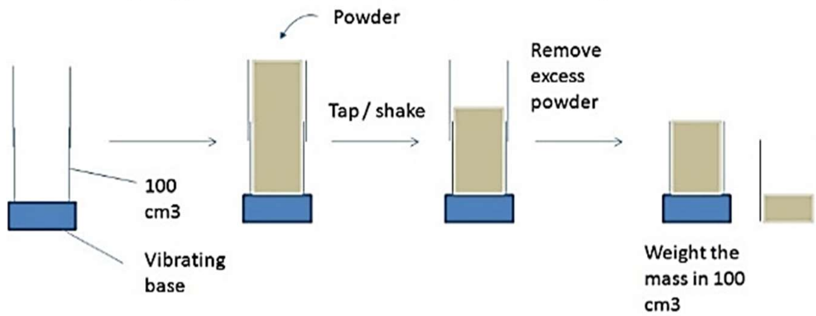

Fig.5 Loose BD and Tapped BD.

C. New Design Considerations:

a. Modified outer tube of the screw adding pores area at both ends of the tube.
b. Mesh added on the pores area. Mesh size 100.
c. Vacuum pump used for the suction.
d. Auger screw selected of dia. 67mm. calculations shown in chart 1.
e. Product used is wheat flour with loose BD 0.62g/cc

Fig. 6 Modified Auger Tube.

Table 2: Specifications of the Vacuum Pump

Parameters of Vacuum Pump	MINK MM 1104 BV

Nominal Pumping Speed	**62/75 m^3/h(50/60 Hz)**
Ultimate Pressure	**60 hPa(mbar) (50/60 Hz)**
Nominal Motor Rating	**1.3 Kw (50Hz) 1.5 /1.7 Kw(50/60 Hz)**
Nominal Motor Speed	**1500/1800 min^{-1}(50/60 Hz)**
Noise Level(ISO2151)	**66/70 Db(A) (50/60Hz)**
Weight Approx.	**180kg(50/60 Hz)**
Dimensions (LxWxH)	**970 x 430 x 410 mm (50 /60 Hz)**
Gas inlet /Outlet	**G1 ¼" / G 1"**

D. Vacuum Added to Top and Bottom Side of the Tube:

Fig.7 Experimental set-up.

Vacuum created on both top and bottom chamber by using the vacuum pump. After very fine dust and air is extracted, it makes the product bulkier. While the fine dust and air voids getting extracted from powder. Vertical rotating screw keeps dispensing the product in sachets. Fine dust is filtered through the filter and collected at another filtering point. Air suction is kept on the whole time.

VI. RESULTS AND DISCUSSION

As per our methodology, first we selected the screw as per standard calculations and then design modifications has been carried out on the outer tube of the auger screw, then trials taken on new set-up for 1 kg weight and 55 dosing per minute. The trial results show that, by using vacuum in the auger tube, the product loose BD is turned into tapped BD, hence the bulk density is increasing. The increase in bulk density is resulting into improved weight accuracy and improved efficiency of the system. Also, the excessive dust in the product is getting removed by vacuum operation. The below table shows the existing and improved results with modified system.

Table 3. Results of Existing and Modified System

Parameters	Existing System	Modified System
Product BD	0.62	0.79
Filling Accuracy	±2.5%	±1%

Dosing Speed	45 dpm	55- 57dpm

VII. CONCLUSION

Design modification is carried out in the existing auger tube, and loose BD changed to tapped BD using the vacuum connection. The modified system has advantages on existing system as below.

1. Improved dosing accuracy
2. Improved dosing system efficiency
3. Removal of excessive dust in the product.
4. Increase in accuracy and reduction in dust formation will increase the production rate, reduce the laminate wastage and helps in cost saving.

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